EDGEWOOD
CHEMICAL BIOLOGICAL CENTER
U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND

ECBC-TR-013

# DOMESTIC PREPAREDNESS PROGRAM: TEST FOR MUSTARD (HD) LIQUID CHALLENGE OF HOSES FOR SELF-CONTAINED BREATHING APPARATUS (SCBA)

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March 1999



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The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorizing documents.

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*



| 1. AGENCY USE ONLY *(Leave Blank)* | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | 1999 March | Final; 98 May – 98 Jul |

**4. TITLE AND SUBTITLE**

Domestic Preparedness Program: Test for Mustard (HD) Liquid Challenge of Hoses for Self-Contained Breathing Apparatus (SCBA)

**5. FUNDING NUMBERS**

None

**6. AUTHOR(S)**

Sneeringer, Paul V., and Campbell, Lee E.

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**

DIR, ECBC,* ATTN: AMSSB-REN-SO, APG, MD 21010-5424

**8. PERFORMING ORGANIZATION REPORT NUMBER**

ECBC-TR-013

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**

*When this work was conducted, the U.S. Army Edgewood Chemical Biological Center (ECBC) was known as the U.S. Army Edgewood Research, Development and Engineering Center (ERDEC).

**12a. DISTRIBUTION/AVAILABILITY STATEMENT**

Approved for public release; distribution is unlimited.

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** *(Maximum 200 words)*

Under the Domestic Preparedness Expert Assistance Personal Protection Equipment Evaluation Program, the U.S. Army Edgewood Chemical Biological Center was tasked to perform testing of hoses for the self-contained breathing apparatus against permeation by liquid mustard (HD). Seven hoses from each of six manufacturers were tested using a standard method (MIL-STD-282, Method 204.1.2). The requirements were that no HD should permeate the hoses within 1 hr after the HD challenge was initiated. None of the 42 hoses tested showed any permeation within 1 hr.

**14. SUBJECT TERMS**

Hoses
Permeation test
Domestic preparedness
Self-contained breathing apparatus

**15. NUMBER OF PAGES**

11

**16. PRICE CODE**

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| **UNCLASSIFIED** | **UNCLASSIFIED** | **UNCLASSIFIED** | **UL** |

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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## PREFACE

The work described in this report was authorized under the Expert Assistance Personal Protection Equipment Evaluation Program for the Program Director for Domestic Preparedness. This work was started in May 1998 and completed in July 1998.

The use of either trade or manufacturers' names in this report does not constitute an official endorsement of any commercial products. This report may not be cited for purposes of advertisement.

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## Acknowledgments

The authors thank Patricia Boone, Aaron Hyre, and Alfred Ciolfi for their laboratory expertise during the agent testing.

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DOMESTIC PREPAREDNESS PROGRAM:
TEST FOR MUSTARD (HD) LIQUID CHALLENGE
OF HOSES FOR SELF-CONTAINED BREATHING APPARATUS (SCBA)

## 1. INTRODUCTION

Under the Domestic Preparedness (DP) Expert Assistance Personal Protection Equipment (PPE) Evaluation Program, the U.S. Army Edgewood Chemical Biological Center (ECBC) was tasked to perform testing of hoses for the self-contained breathing apparatus (SCBA) against permeation by liquid mustard (HD). The military chemical agent, HD, is a vesicant (induces blistering). It is used as a standard permeation test challenge, because it permeates most protective materials more rapidly than any other chemical agent, thus shortening the test time to detection of permeation. The DP Program includes response to incidents of military chemical agent, thus shortening the test time to detection of permeation. The DP Program includes response to incidents of military chemical agents dispersed in a civilian setting, therefore the requirement for testing responders' personal protective gear against these agents. If the components of the PPE resist HD permeation for a specified time, it is certain that the components will resist permeation by any other chemical agent for the same time. The actual permeation testing was assigned to the Chemical Evaluation Laboratory, Surety Team, Engineering Directorate, which has many years experience in testing military breathing hoses against HD, using a standard method. The requirement for test results was given to the laboratory as 1 hr resistance to HD permeation. The purpose of the test was to collect data on the performance of the hoses against HD challenges.

## 2. METHODOLOGY

### 2.1 HD Permeation Test.

The HD permeation test used in this study is based on the following references:

- MIL-STD-282, 28 May 1956, Department of Defense Test Method Standard, Notice 4, Filter Units, Protective Clothing, Gas-Mask Components and Related Products: Performance Test Methods, Method 204.1.2 Mustard Resistance of Impermeable Materials (Static Diffusion Method)

- SOP CR9-ISP011-96C, Testing Resistance of Impermeable Material Hoses to Mustard (HD), VX, TGD, and HD Simulant

- MIL-H-14506, Hose: For Filter Units

- EA-H-1350, Hose for Chemical Biological Aircrew Mask XM43

MIL-STD-282 provides all the details of the HD permeation test, but does not specify how to test odd items such as hoses or irregularly shaped items, nor does it specify how long items should resist HD permeation. These requirements are provided in military specifications and purchase descriptions, such as MIL-H-14506 and EA-H-1350 and in laboratory SOPs. This study used the provisions of MIL-STD-282, MIL-H-14506, and EA-H-1350 without

modifications, and the testing was performed in accordance with SOP CR9-ISP011-96C, which covers all steps of the operation and all safety precautions necessary. The safety precautions include such things as performing the operation inside a certified fume hood, wearing butyl rubber gloves when handling HD, use of a protective mask, appropriate decontamination procedures for the agent involved, and authorized disposal procedures.

2.2 Test Method.

Mustard permeation testing is performed in test apparatus Q170, which is a closed box with thermostat controls, at a temperature of 37 °C. An internal fan circulates the air to maintain the temperature, and a bed of Whetlerite (activated, impregnated carbon) is used to adsorb any HD vapors that escape into the chamber. The test items are placed on glass trays that divide the chamber into upper and lower portions. A window is installed in the wall of the lower chamber through which the underside of the test items can be observed with a slanted mirror in the lower chamber. Indicator paper in intimate contact with the underside of the test item indicates when HD has permeated the item. The indicator paper is made by dipping filter paper (NNN-P-1475B) into an aqueous solution of congo red dye (0.1%), allowing it to dry, and storing it in an acid-free environment until required for use. To use the indicator paper, drops of S-328 solution are placed on the paper, allowed to dry, and the prepared paper is then placed under the test item so the S-328 drops are at the spot where HD is expected to permeate the item. When HD contacts the S-328 spots, blue spots form; HD reacts with S-328 to form hydrogen chloride (HCl), which reacts with congo red dye to turn the dye blue. Tetrachloro-7,8-diphenylglycouril (S-328) is dissolved in tetrachloroethane (0.5 g S-328, 0.1 g sodium carbonate in 10 mL), and the solution can be used for 2-3 days after preparation. The S-328/HD/congo red reaction is sensitive to a permeation of HD vapor of $4\mu g/cm^2$.

2.3 Test Operation.

Prepare the hose specimen by cutting a 6-in. section from the hose. Plug one end of the specimen with an impermeable plug (e.g., a short section of Plexiglas rod machined so as to be inserted tightly into the bore of the hose). Wrap a strip of indicator paper tightly around the hose specimen and secure it with rubber bands so that the paper is in intimate contact with the surface of the hose. If the hose is corrugated, use a streak of the S-328 solution instead of dots on the congo red paper to assure that the hose will contact the S-328. Lay the specimen in a holder in the horizontal position such that the S-328 (streak or dots) is on the underside. Use a long tip Pasteur pipet to place a 3-4 in. line of liquid HD inside the hose (indicated by the length of the pipet emerging from the bore). Plug the second end of the hose. Place the holder with hose specimen on the upper tray of the Q170 test apparatus and close the door. Start a timer when the HD is placed inside the hose. Observe the congo red indicator paper through the window and mirror for the appearance of blue color, which indicates that HD has permeated the wall of the hose specimen. Terminate the test when a blue color appears or at 1 hr, whichever occurs first.

2.4 Test Parameters and Observations.

The HD used in this test was a high purity distilled HD, certified for purity and use as a Chemical Agent Standard Analytical Reference Material (CASARM) by Research and Technology Directorate, ECBC. The temperature controller and readout for the Q170 test

apparatus was calibrated in accordance with Department of Defense (DoD) regulations. Liquid HD is a more severe challenge than HD vapor and will permeate the challenged material much sooner; thus, using liquid HD is a more conservative test. It is not anticipated that these hoses will be used in an environment where contact with liquid HD is possible. Manufacturers' instruction manuals state that these systems (SCBA) are not for use in atmospheres Immediately Dangerous to Life or Health (IDLH) or where oxygen levels are <19.5%. The IDLH values have not been established for HD, because workers will already be required to wear these types of respiratory protection at concentrations much lower than what is considered IDLH for HD, due to concerns over carcinogenicity. It is required that HD agent concentrations and projected stay times are such that emergency response personnel using SCBA systems will not exceed the Airborne Exposure Limit (AEL) of 0.003 $mg/m^3$, which is a ceiling value referring to the maximum exposure concentration at any time, for any duration (AR385-61, para 2-5, n (2) and Tables 2-2 and 2-3). Performing the test at 37 °C is also conservative, because permeation rates increase linearly with temperature, and the SCBA will most likely be used at or near room temperature (25 °C). The hoses are not inspected for pinholes, discontinuities, flaws, or other imperfections, because the permeation test is designed to detect pinholes and ease of permeation, and the samples submitted for testing presumably were randomly sampled and represent the items available to the public. Also, quality assurance personnel, at the manufacturing plant, will presumably have inspected and rejected hoses that did not meet physical requirements, including wall thickness, discontinuities, and other flaws. The permeation test for hoses requires that the HD be placed inside the hose, rather than on the outer surface as would occur in an actual contamination. This is done for convenience, because HD liquid placed on the outer surface would run off or would have to be placed in a pool under the hose where it would be subject to evaporation, thereby gradually reducing the total challenge. Detecting permeation inside the hose is also problematical and would needlessly complicate the test. A pool of liquid HD inside the hose will be a driving force for permeation directly through the hose wall to the point where the S-328 indicator is located. The HD that migrates to other sections of the hose wall, including wicking through any fabric embedded in the polymer, would have no effect on the permeation rate because of the relatively large quantity of challenge HD compared with the quantity that actually permeates and is detected on the indicator paper.

## 3. MATERIALS, REQUIREMENTS, AND TEST RESULTS

### 3.1 Test Hoses.

Seven SCBA hoses from each of six manufacturers were provided for the test. The manufacturers and SCBA hose identification are as follows:

| | |
|---|---|
| Racal™ Safety and Health | Assembly, Low Pressure (36Z-16-56R01) |
| Survivair® | Low Pressure Assembly (910647) |
| Mine Safety Appliance | Flexible, corrugated, Hose |
| Interspiro | Hose, Breathing, w/Bypass Valve |
| Draegar Safety, Incorporated | Evolution, with Hose |
| Scott Aviation Health & Safety | Assembly, Low Pressure, E-Z Flo |

3.2 Requirements.

The permeation requirements are presented in Table 1.

Table 1. Permeation Requirements

| Sample Size | Temperature (°C) | HD Challenge (g) | No. of Samples | Hours Required |
|---|---|---|---|---|
| 6 in. | 37 | 0.5 – 0.7 | 7 | 1 |

3.3 Results.

The test results are presented in Table 2.

Table 2. Permeation of Hoses by Liquid HD

| Sample Tested | Requirement (hr) | No. of Tests | Results (hr) |
|---|---|---|---|
| Racal Safety & Health (36Z-16-56R01) | >1 | 7 | >1 |
| Survivair (910647) | >1 | 7 | >1 |
| Mine Safety Appliance, Flexible Corrugated Hose | >1 | 7 | >1 |
| Interspiro, Breathing Hose with Bypass Valve | >1 | 7 | >1 |
| Draeger, Safety, Inc., Evolution, with Hose | >1 | 7 | >1 |
| Scott Aviation Health and Safety, E-Z Flo | >1 | 7 | >1 |

4. CONCLUSIONS

4.1 Summary.

For each manufacturer, seven individual hoses were sampled and one permeation test run on each, for a total of 42 tests. The test requirement was for no permeation of liquid mustard (HD) to occur before 1 hr of exposure to liquid HD. Each sample tested resisted permeation to HD for at least 1 hr. It is concluded that each type of hose tested will meet the requirements for use in an HD-contaminated atmosphere, where the self-contained breathing apparatus (SCBA) is authorized to be used.

4.2 Recommendation.

The hoses for the SCBA tested as indicated in this report will resist permeation by large quantities of liquid HD and are qualified for use on operations where there is potential exposure to liquid or vaporous HD for at least 1 hr.